Search for New Particles Decaying to Dijets in Run 2

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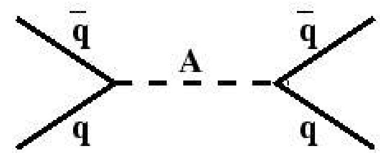
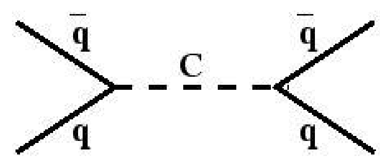
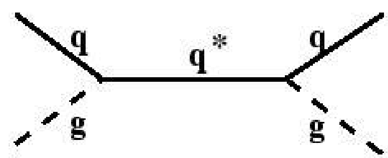
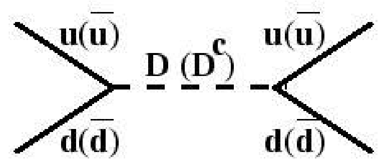
Introduction

- Motivation
  - Search for resonances.
  - Find them or set limits.
- Strategy
  - Repeat Run 1 analysis as closely as possible.
  - We've done this before and can benefit from our run 1 experience
    - PRD 55, R5263 (1997)
    - PRL 74, 3538 (1995)
  - Allows direct comparison of run 2 with run 1 data.
    - Provides sanity check on jet energy scale.

New Particles That Decay to Dijets

Model	Particle	Production/Decay	J^P(color) & $\Gamma/2$
Chiral Color SU(3)L x SU(3)R	Axigluon A		$1^+(8)$ .05 M
Extended Technicolor	Coloron C		$1^-(8)$ .05 M
Composite Fermions	Excited Quark q^*		$1/2^+(3)$ .02 M
Superstring Inspired E6 Models	Diquarks D, D^c		$0^+(\bar{3})$ .004 M

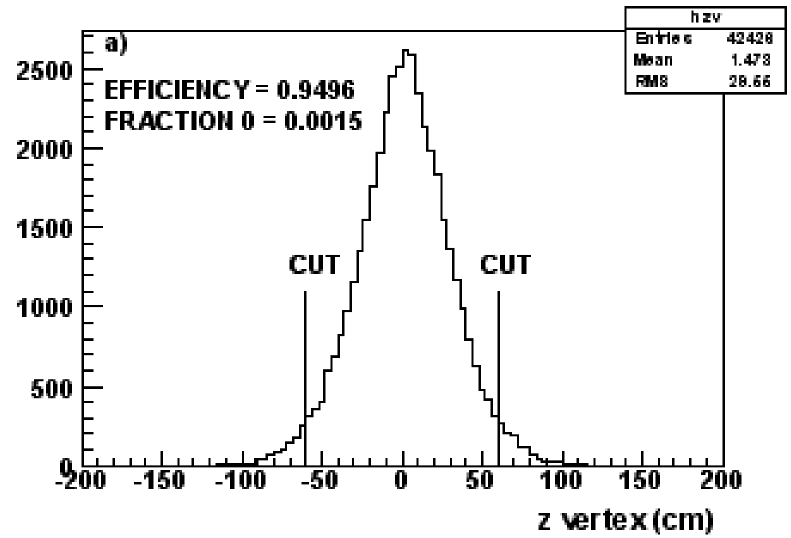
Dijet Mass Analysis
(CDF 6248)

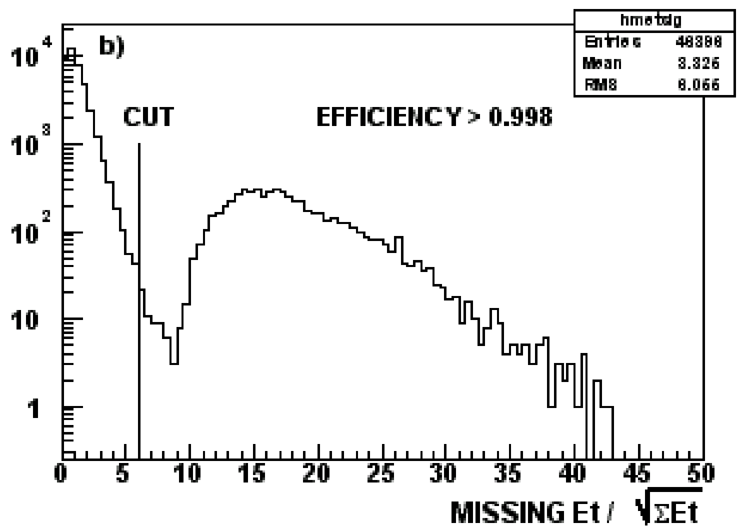
- As in run 1, use J20, J50, J70 & J100 triggers.
  - DataAccess ntuples using 4.9.1 reprocessing of Feb – Dec 2002 data.
  - 75 pb^{-1} after selection of runs good for L1, L2, and Calorimetry (90 pb^{-1} before).
- As in run 1, we apply the following cuts.
  - $|$ Z Vertex $| < 60$ cm to insure cal towers project from vertex. Efficiency $\cong$ 95%.
  - Missing $E_T/\mathrm{sqrt}(\Sigma E_T) < 6.0$ to eliminate cosmic rays.
  - $\Sigma E < 2.2$ TeV (2.0 TeV in run 1) to eliminate unphysical noise.
- Get the two highest E_T jets, with cone R=0.7, and correct the energy.
  - Use latest official jet correction code JetEnergyCorrection.cc on Jan. 15, 2003.
    - Relative correction vs. detector η comes from dijet balancing in all jet samples.
    - Absolute corrections for central response, out-of-cone energy & und event from run 1
    - Jet E-scale using photon-jet balancing results in run 2 and run 1 from G. Latino.
- As in run 1, require each jet have $|\eta| < 2$, $|\cos\theta^*| = |\tanh([\eta_1-\eta_2]/2)| < 2/3$.
  - Reduces QCD background (t-channel) more than resonances (s-channel)
- As in run 1, dijet mass $M = \mathrm{sqrt}(E^2 - \bar{p}^2)$, where $E=E_1+E_2$, $\bar{p} = \bar{p}_1 + \bar{p}_2$.

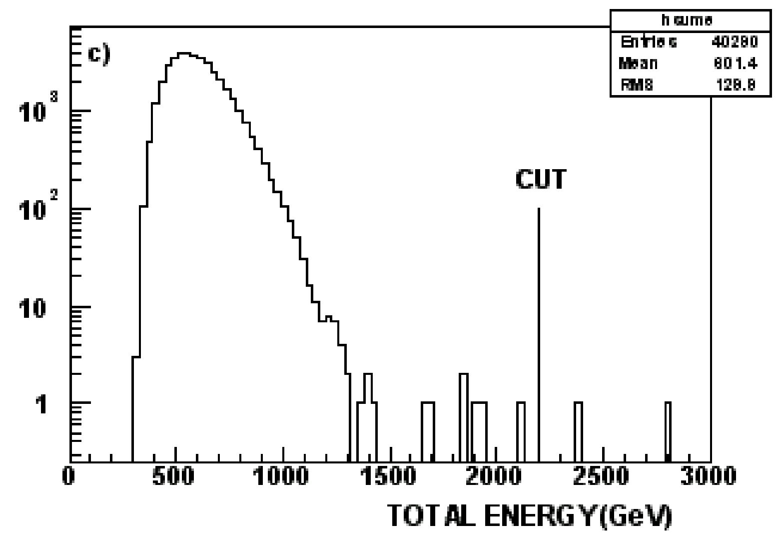
Selection Cuts in J100 Sample

Includes all analysis cuts for final sample except cut shown

- z vertex cut is 95% efficient.
  - Vertex strategy 1 algorithm fails on 0.2% of events & z=0.0 is assigned.
- Missing Et significance cut is crucial for elimination of cosmics rays
  - Efficiency > 99.8% for J100 sample
- Total energy cut for obvious junk.
  - Events removed are at low mass.







Trigger Efficiency and Luminosity

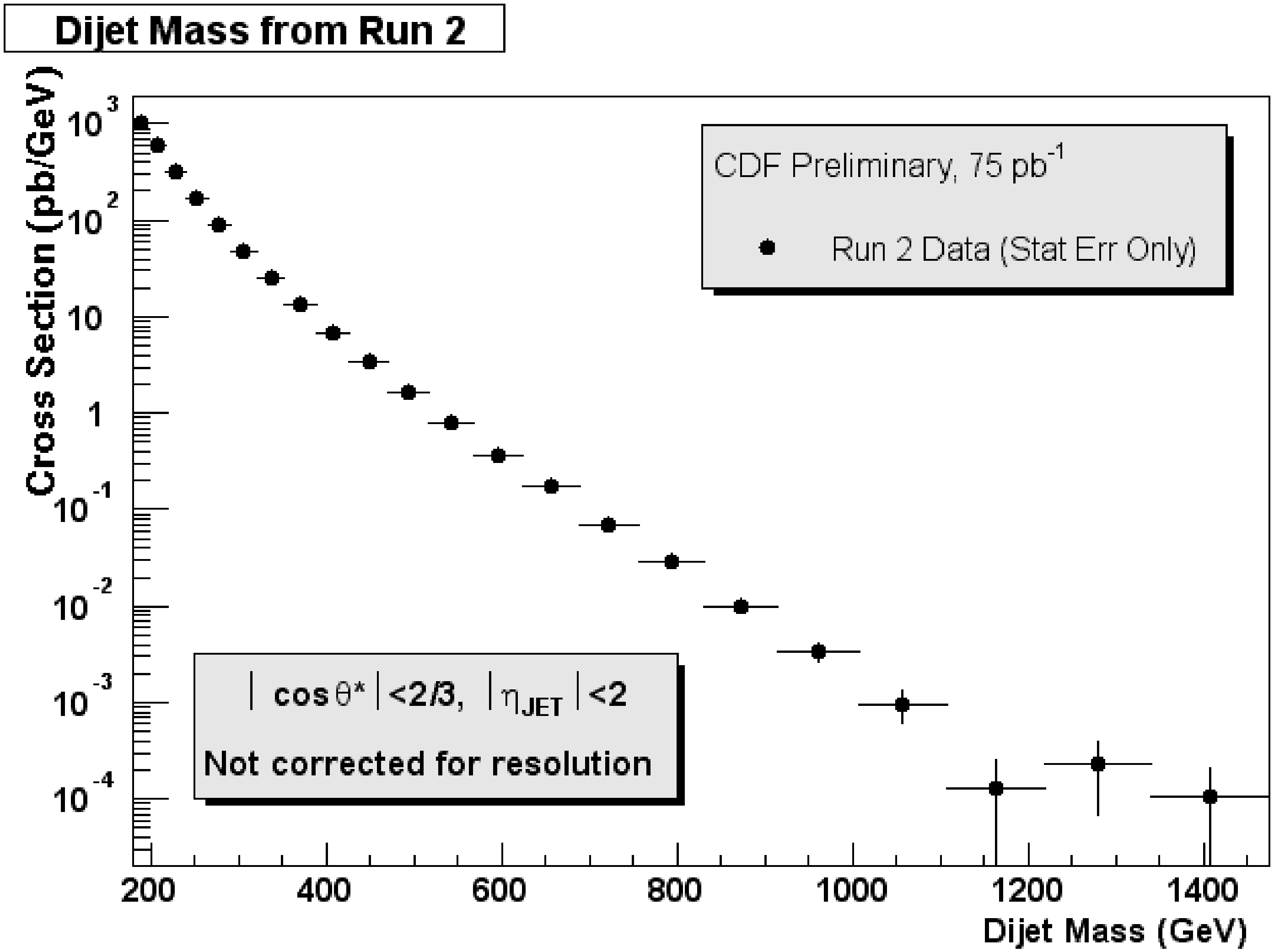
- Use events with full trigger efficiency
  - Measure the trigger efficiencies in analysis bins.
  - Require prior bin to have >99% efficiency.
  - Makes trigger systematics negligible.
  - Avoids falsely pinning background fit.

- Measured prescales agree with the nominal values.

Trigger	Mass Cut (GeV)		Efficiency at Threshold			Luminosity/Prescale (pb^{-1})		
	Run 1	Run 2	Run 1A	Run 1B	Run 2	Run 1A	Run 1B	Run 2
Jet 20	180	180	1	1	1.00	19.1/500	87.3/1000	74.9/297
Jet 50	241	217	0.99	0.98	1.00	13.1/20	87.3/40	74.9/20
Jet 70	292	292	0.95	0.96	1.00	19.1/6	87.3/8	74.9/8
Jet 100	388	388	0.97	0.96	1.00	19.1/1	87.3/1	74.9/1

- Calculate cross section from rate, luminosity, trigger and z vertex efficiency.

Dijet Mass Distribution



High Mass Dijet Event

Run 152507 event 1222318

Dijet Mass = 1364 GeV (corr)

cos θ^* = 0.30

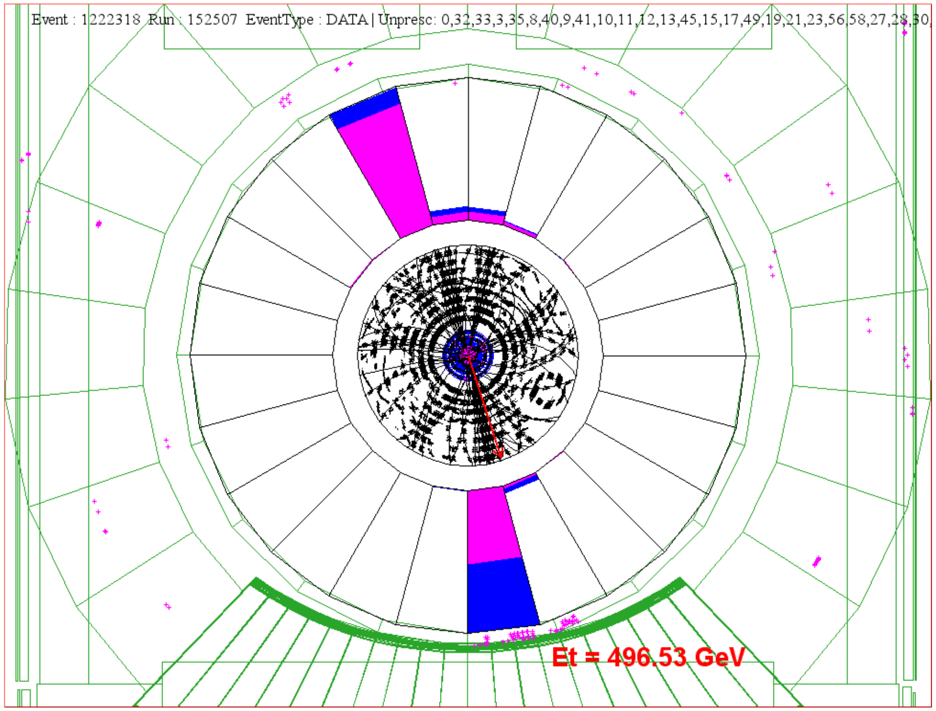
z vertex = -25 cm

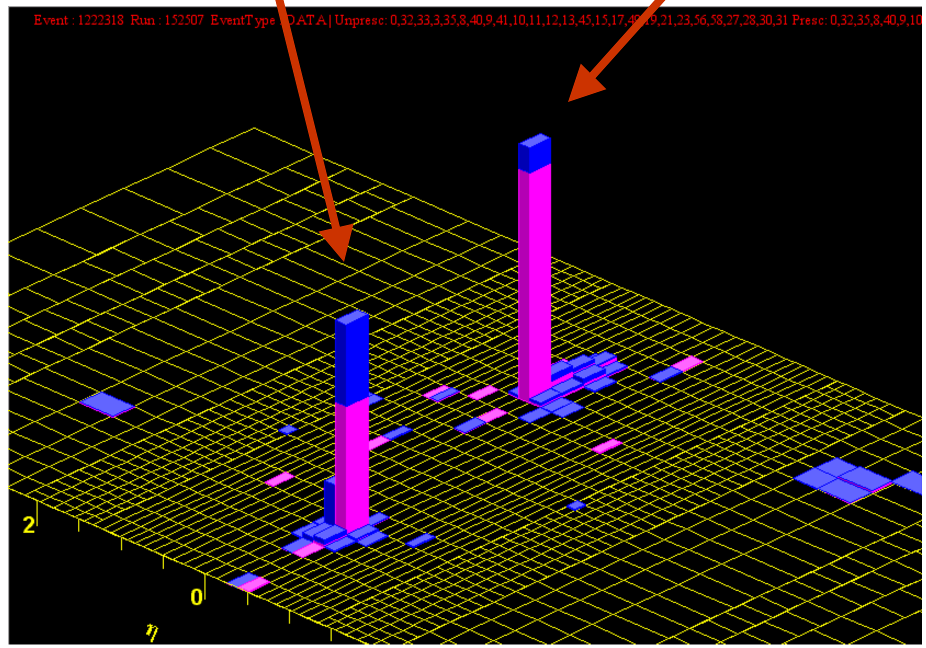
J2 E_T = 633 GeV (corr)
546 GeV (raw)

J2 η = -0.30 (detector)
= -0.19 (correct z)

J1 E_T = 666 GeV (corr)
583 GeV (raw)

J1 η = 0.31 (detector)
= 0.43 (correct z)

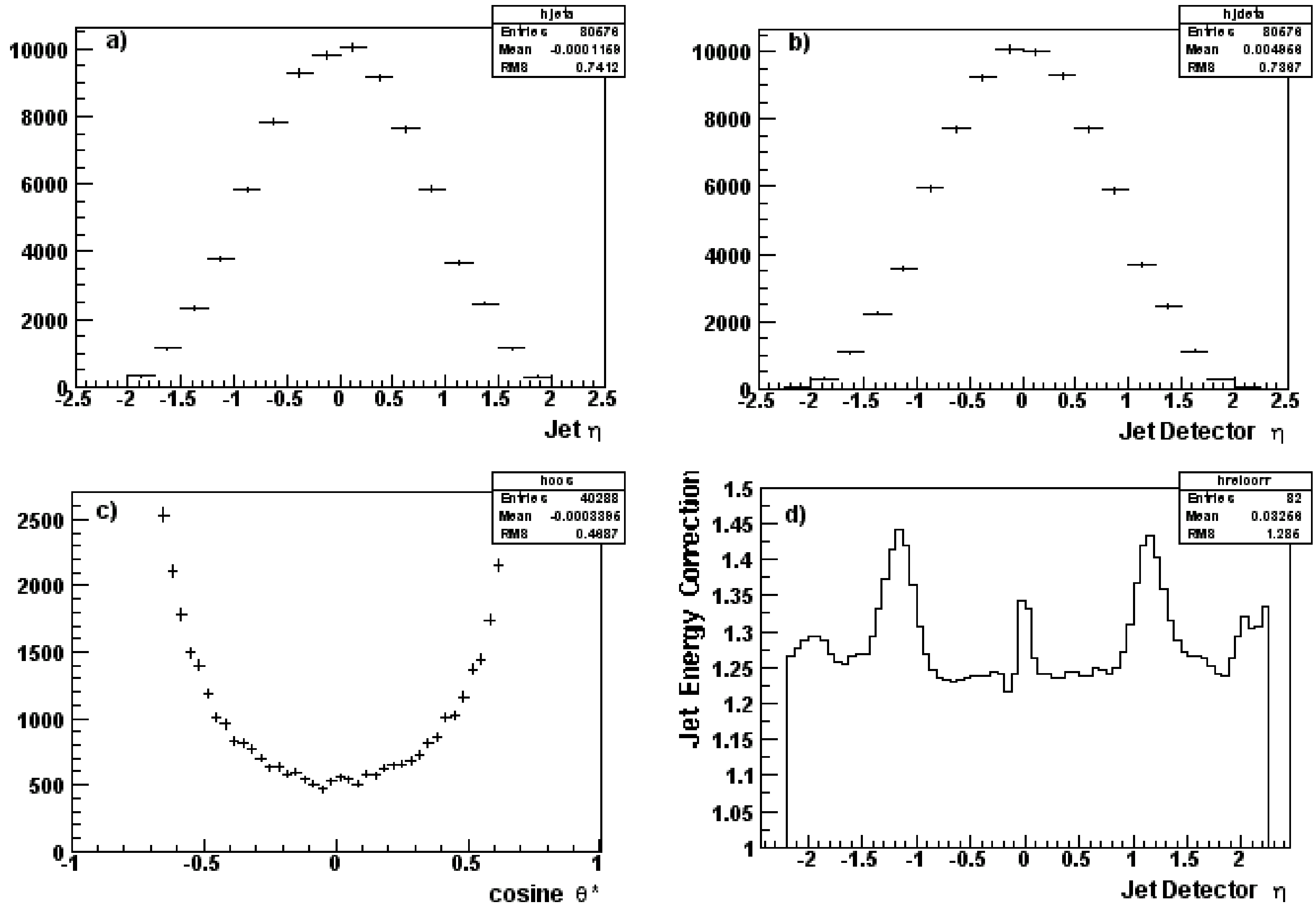




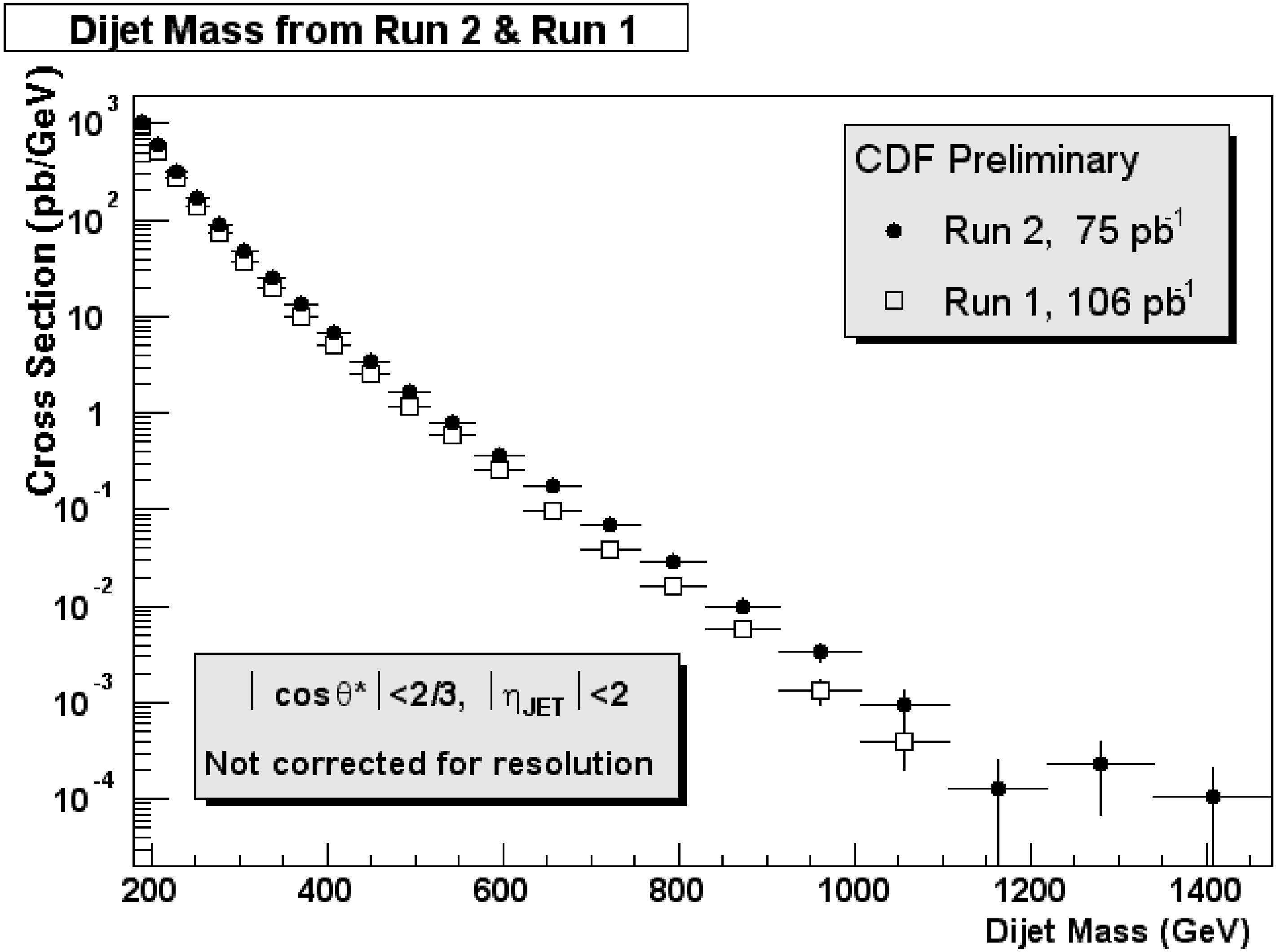
Corrected E_T and mass are preliminary

Angular Variables & Relative Corrections

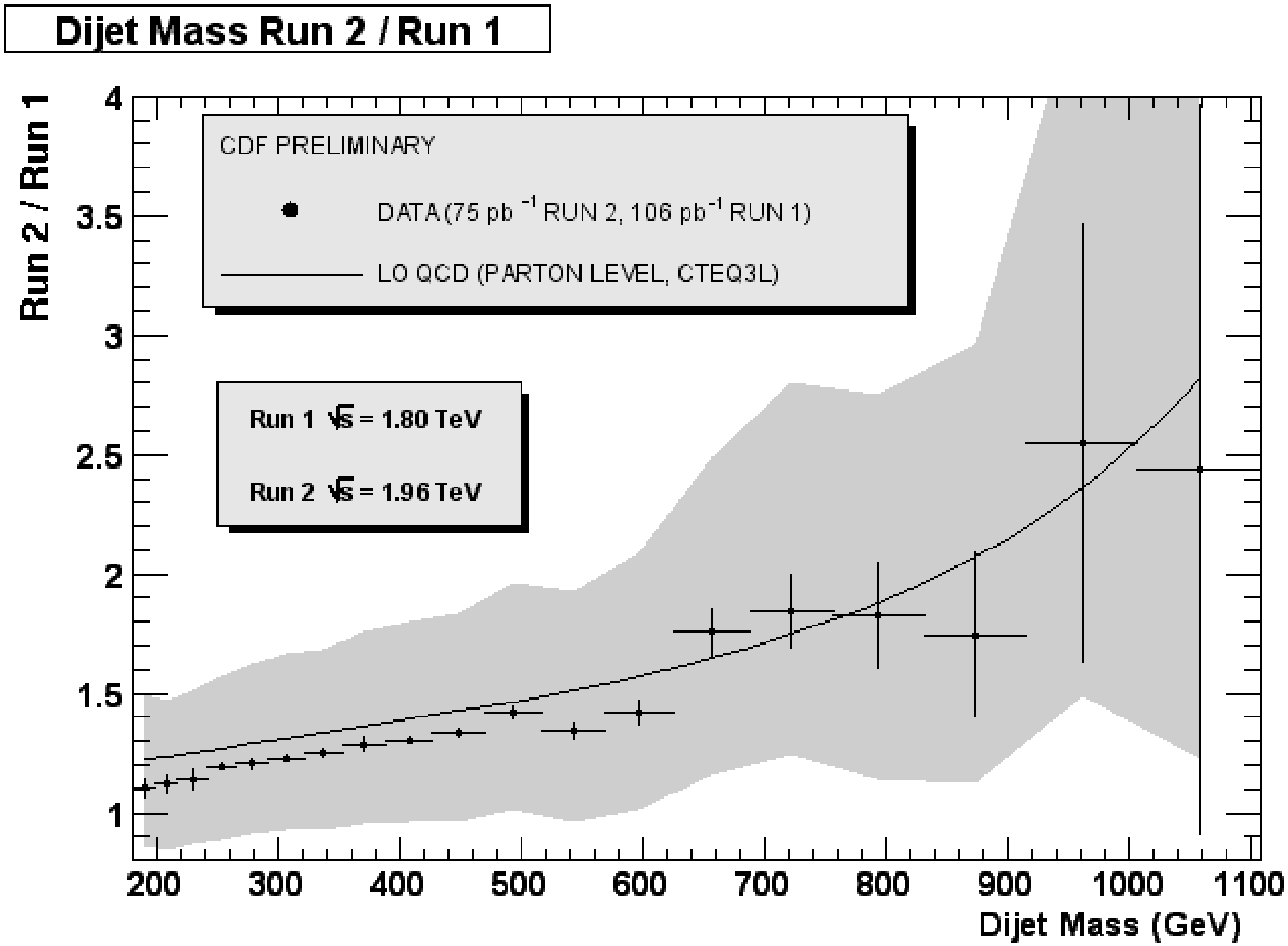
J100 with M>388 GeV



Dijet Mass from Run 2 & Run 1

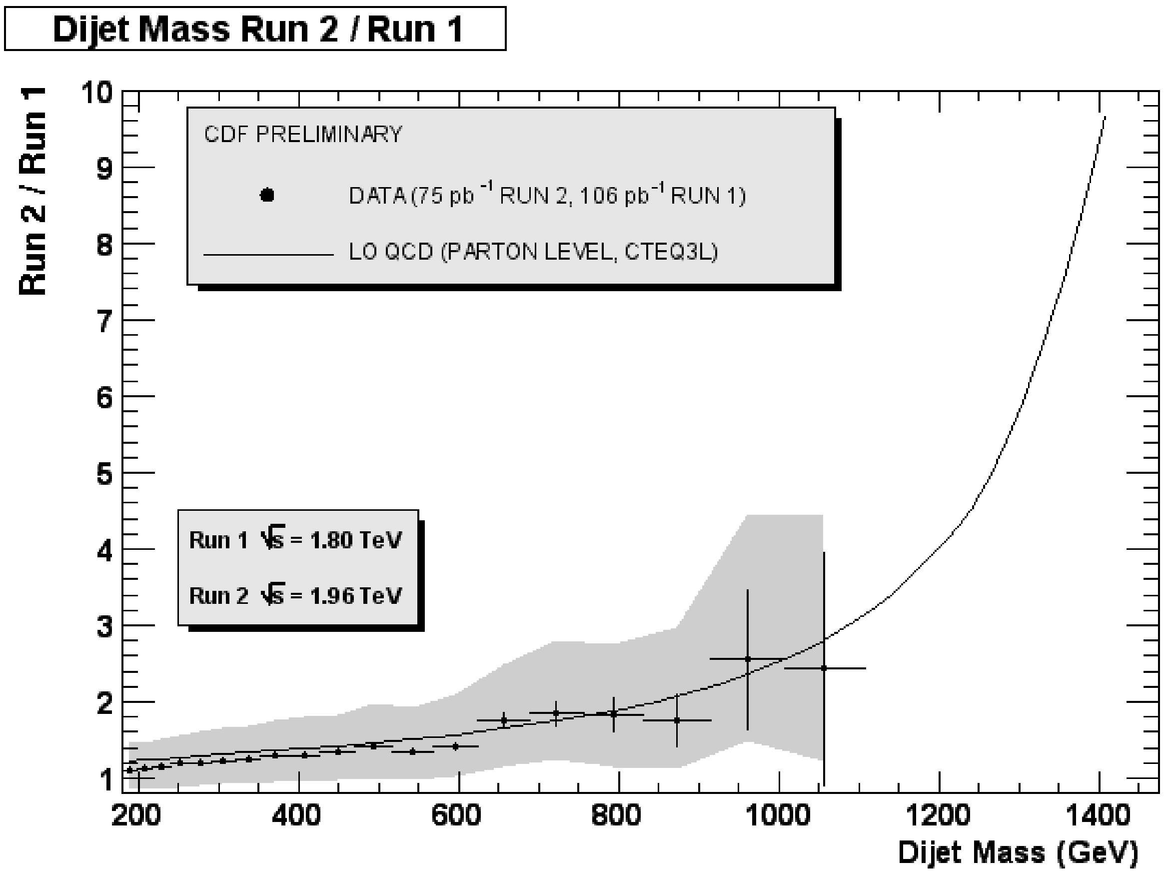


Dijet Mass Ratio: Run 2 / Run 1



- Run 2 / Run 1 agrees with theory to ~10% in rate (~1-2% in energy scale)

Dijet Mass Ratio: Run 2 / Run 1



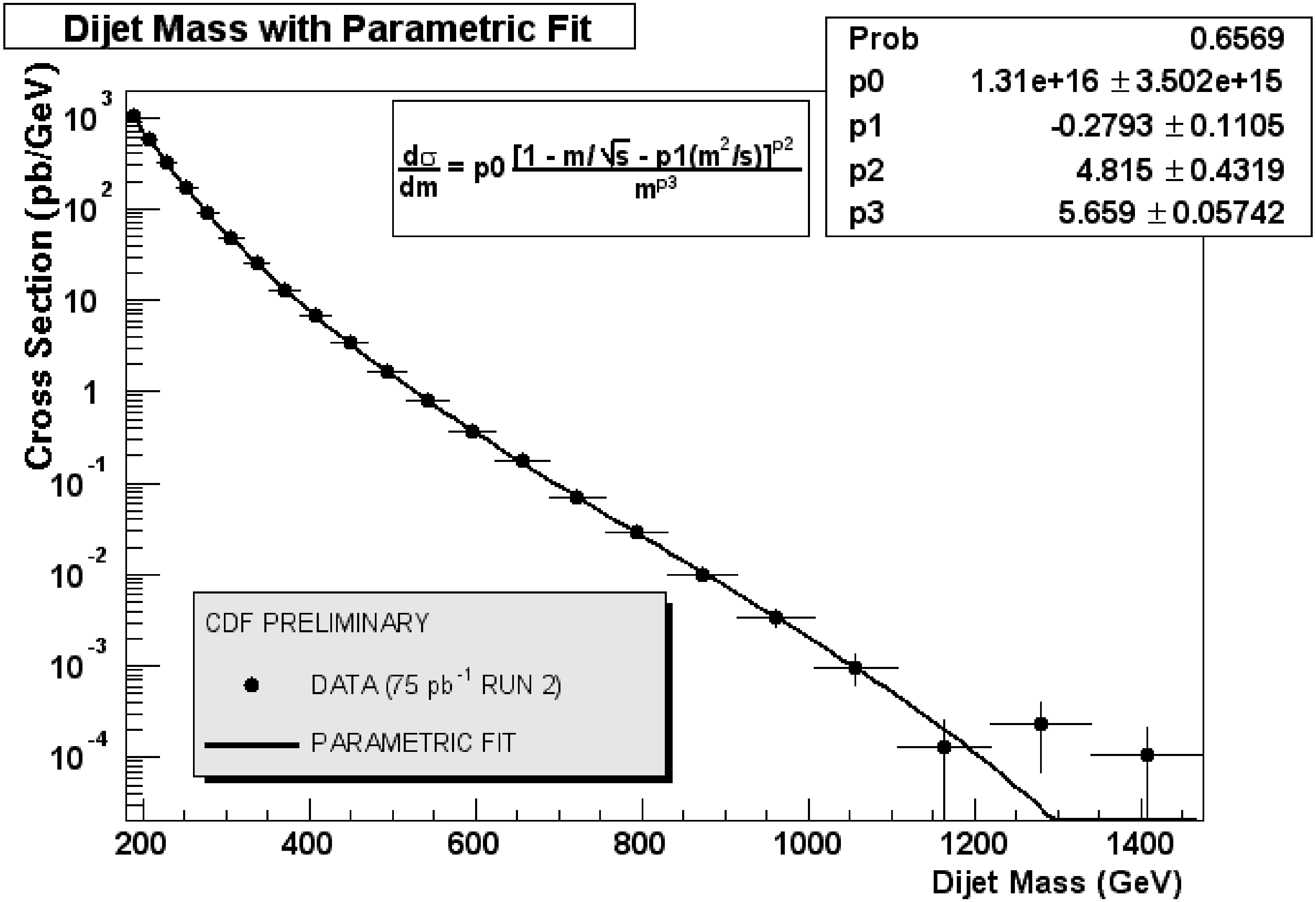
Bin (GeV)	Run 1 (Evts)	Run 2 (Evts)	QCD Ratio
1007-1108	4	7	2.8
1108-1219	0	1	3.6
1219-1341	0	2	5.3
1341-1475	0	1	9.6

- More high mass dijets in run 2 because QCD xsec up to 10 times larger!

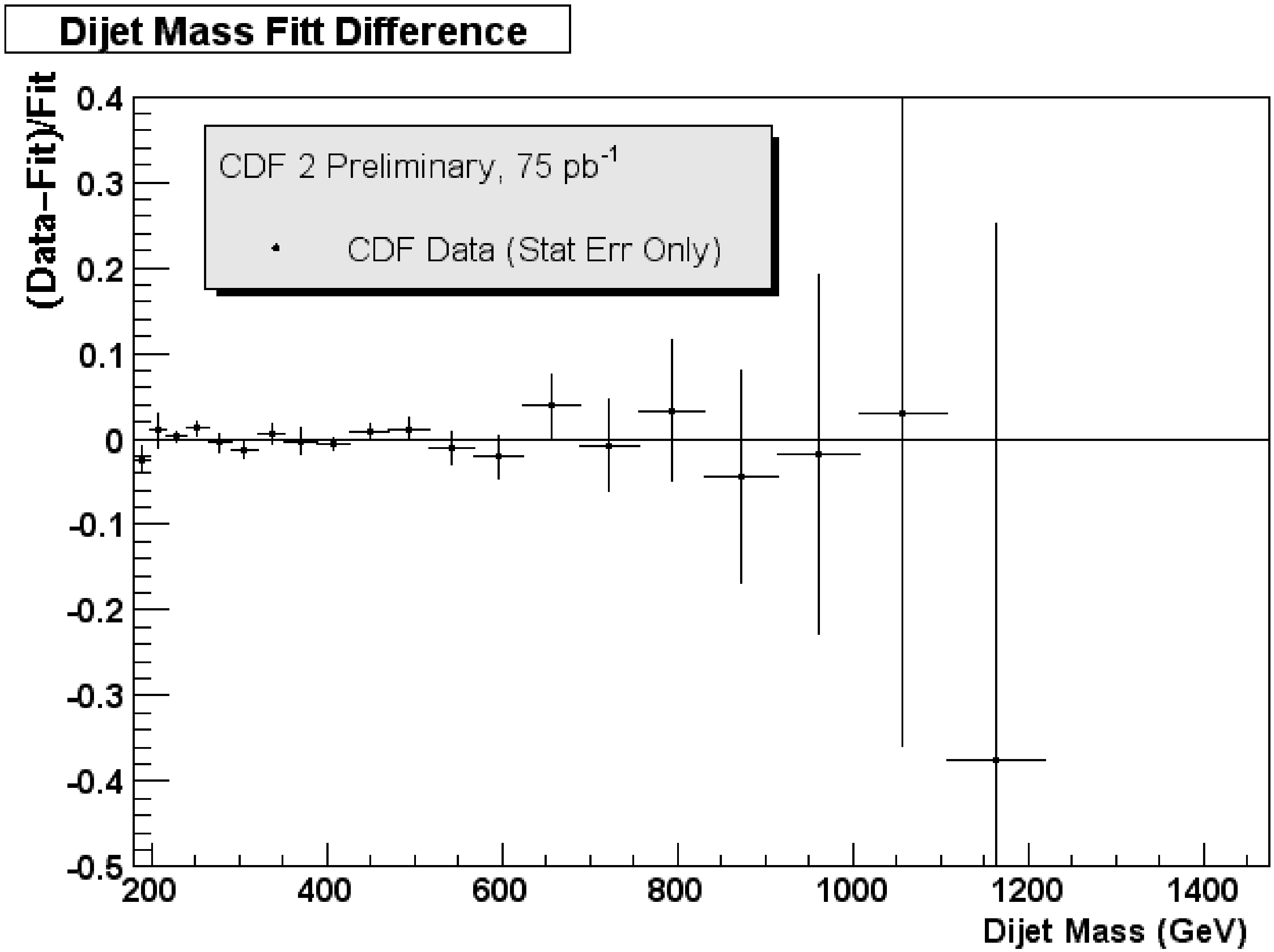
Dijet Mass Search

- Search for resonances
  - As in Run 1, we fit the dijet mass distribution with a background parameterization inspired by QCD.
    - $$\frac{d\sigma}{dm} = \frac{p_0 (1 - m/\sqrt{s} - p_1 m^2/s)^{p_2}}{m^{p_3}}$$
    - Numerator models the $(1\text{-}x)^n$ behavior of parton distributions.
    - Denominator models the $1/m^p$ behavior of QCD matrix element.
  - The fit is good, except perhaps on the tail.
    - P1 controls the downward curvature of the fit at high mass.
    - Constraining P1 > 0.1 fits the tail better, with OK total fit probability.
  - No significant evidence of new particles.

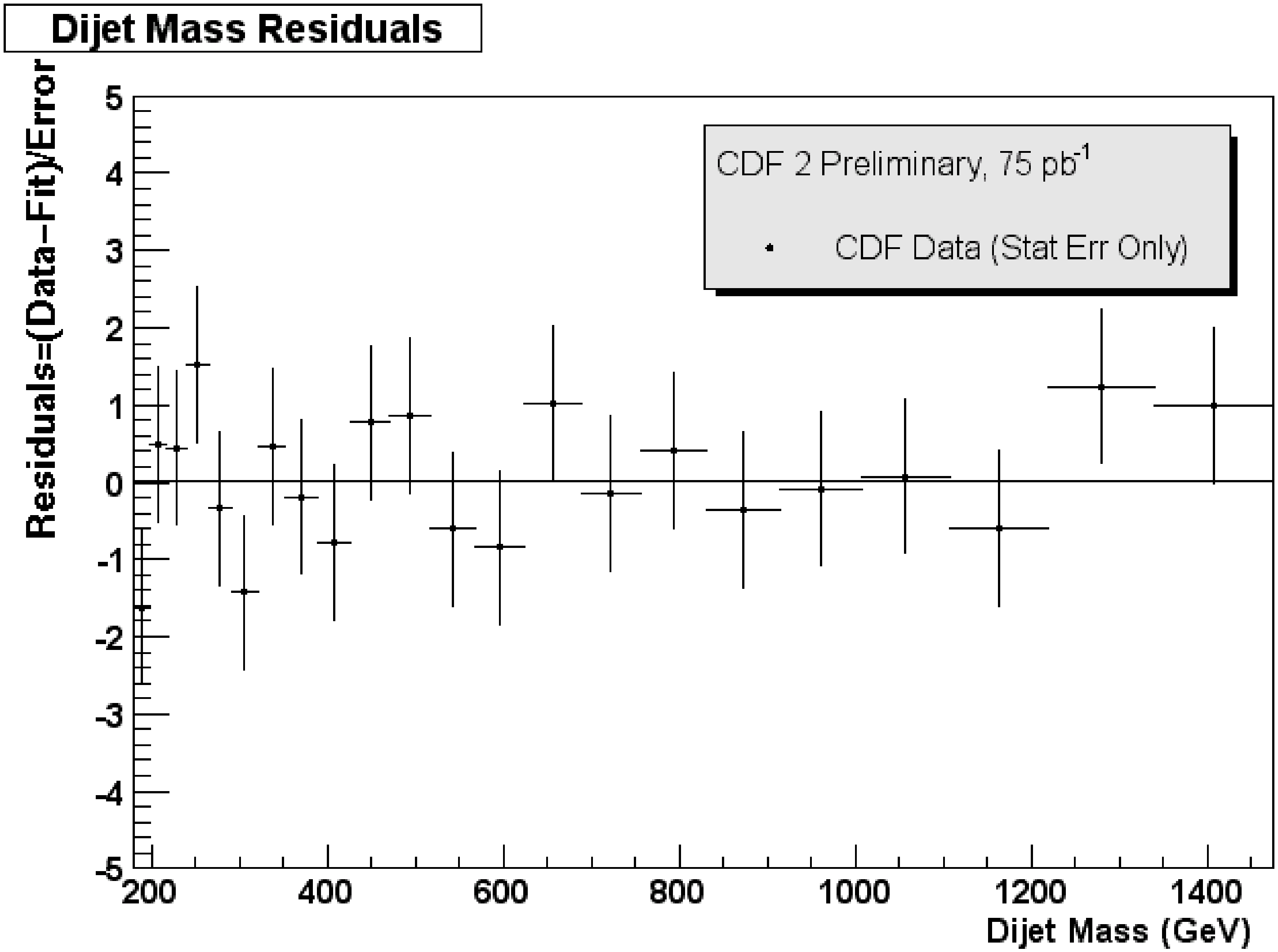
Dijet Mass and Four Parameter Fit



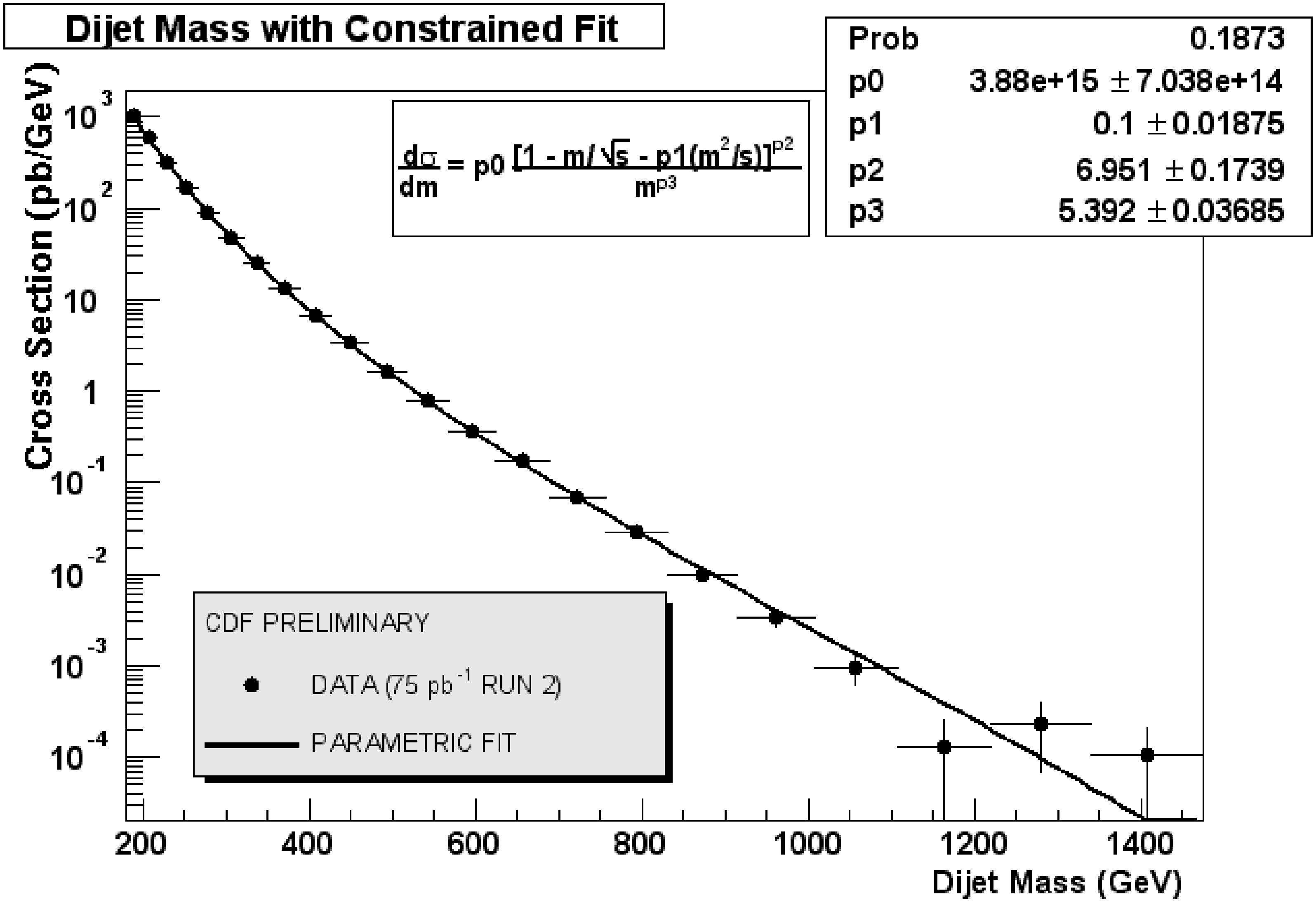
Dijet Mass (Data – Fit) / Fit



Dijet Mass Residuals



Dijet Mass fit constraining P1 $\geq$ 0.1

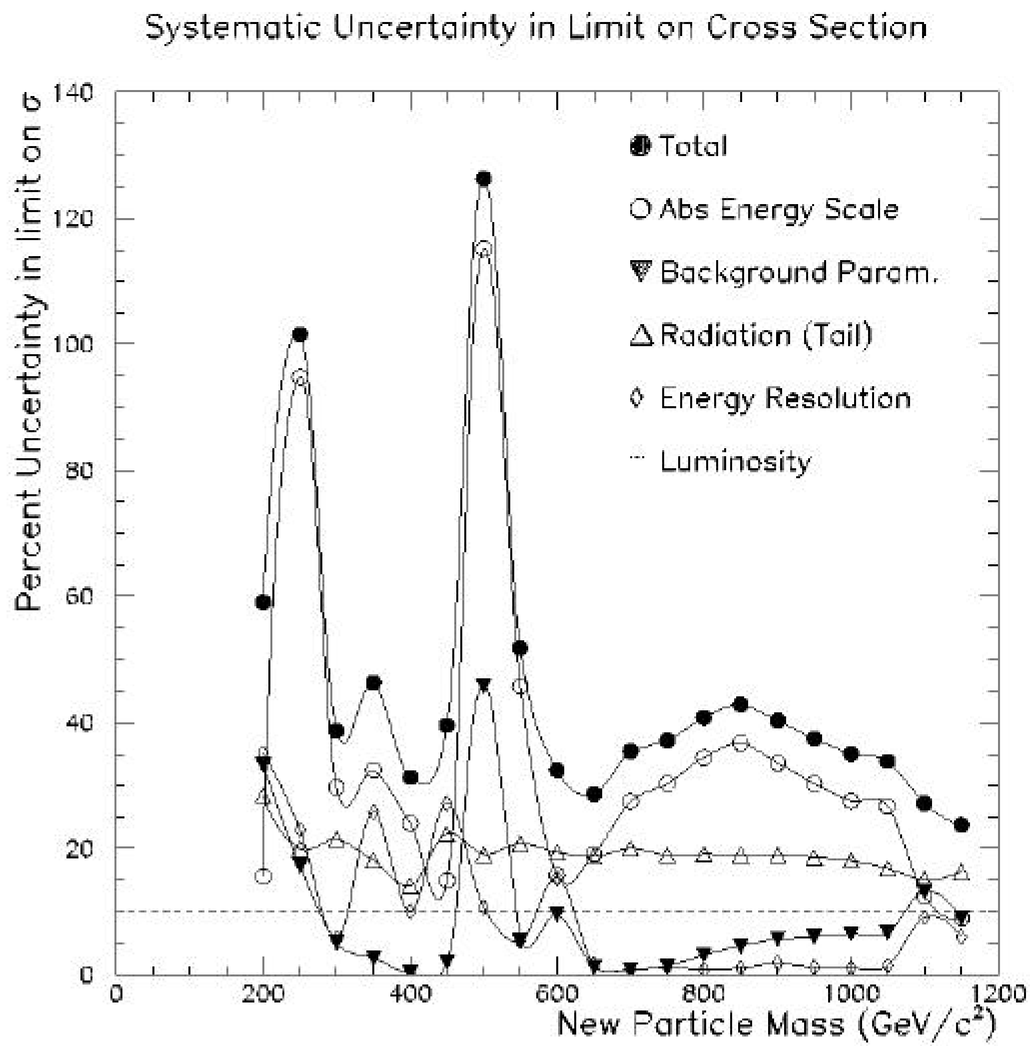


New Particle Limits

- Set upper limits on cross section for new particles.
  - Fit data to background parameterization plus a narrow resonance.
    - Use run 1 simulation of narrow resonances for now.
    - Dijet mass resolution (rms ~ 10%) dominates line shape.
    - There is a long tail to lower masses caused by QCD radiation.
  - Calculate likelihood vs. resonances cross section.
    - Statistical binned likelihood distributions and 95% CL limit points.
    - Recalculate limit for each systematic uncertainty shift.
    - Add resulting systematic shifts in quadrature to get total Gaussian sys.
    - Convolute statistical likelihoods with Gaussian systematic uncertainty.
  - Find 95% CL upper bound on new particle cross section.
    - Both with and w/o systematics.
  - Compare cross section upper limits to new particle theory.
    - As in run 1, we use lowest order predictions, but at $\sqrt{s}$ = 1.96 TeV.
    - We have predictions for Axigluons, colorons, q*, and E_6 diquarks.
    - Read off mass limits from the comparison.

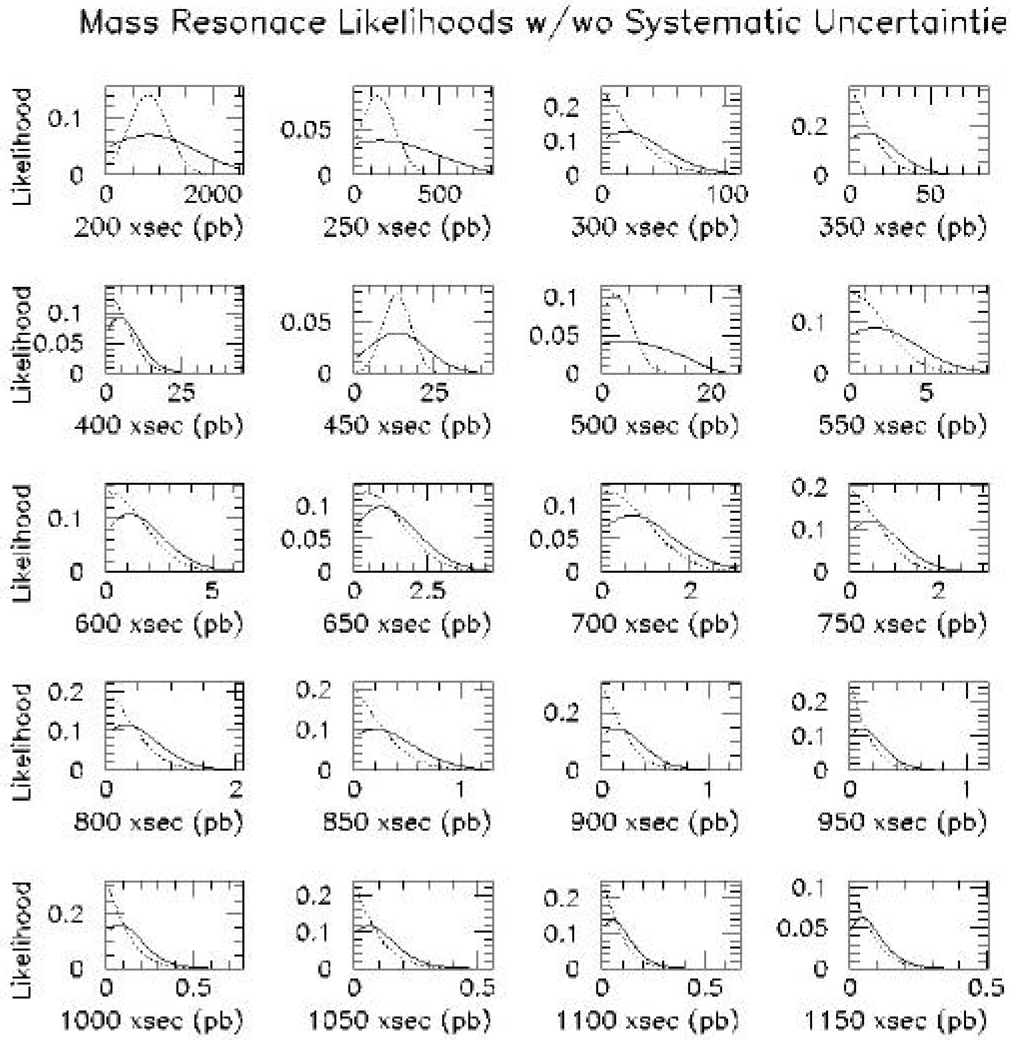
Systematics in Limit on Cross Section

- Systematics
  - Absolute E-Scale
    - 5% systematic.
  - Background Param.
    - Change from 4 to 3 parameter fit.
    - Finds more signal because it fits the data worse.
  - Radiation
    - Cut out half of tail to low mass.
  - Energy Resolution
    - 10% in line shape s
  - Luminosity.
    - 10% at this stage.



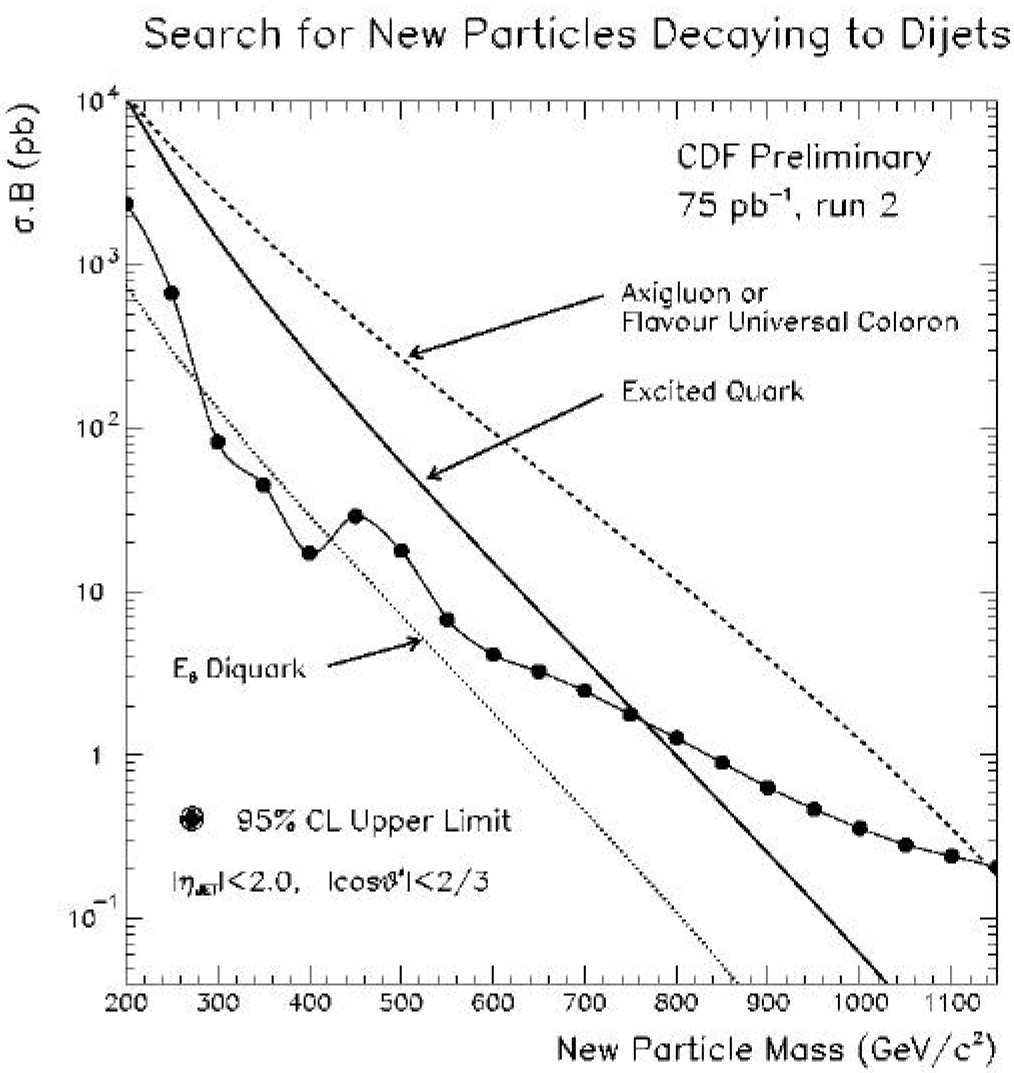
Likelihood Distributions

- Likelihood w/o systematics (dotted) and with systematics (solid) calclulated every 50 GeV for narrow resonances from 200 to 1150 GeV.
- Poisson like statistical likelihoods get smeared out by large Gaussian systematic.
- Integrate likelihood up to 95% area point to find 95% CL upper limit.



Limits on New Particles

- Preliminary excluded masses of new particles at 95% CL in run 2:
  - Axigluon or Coloron
    - Run 2: M <1130 GeV
    - Run 1: M < 980 GeV
  - Excited Quarks
    - Run 2: M < 760 GeV
    - Run 1: M < 760 GeV.
  - E6 Diquark
    - Run 2: 280<M<420 GeV.
    - Run 1: 290<M<420 GeV.



Conclusions

- We have a preliminary dijet mass distribution in run 2.
  - The analysis was as close as possible to that in run 1.
  - The ratio of run 2 to run 1 cross section is close to expected from QCD.
- We've searched for new particles decaying to dijets.
  - Mass distribution is smooth & well fit by background parameterization.
  - 95% CL upper limits found on cross section and mass for new particles.
    - Axigluons or flavor universal colorons excluded for M<1.1 TeV at 95% CL.
    - Excited Quarks excluded for M<760 GeV at 95% CL.
    - E_6 Diquarks excluded for 280<M<420 GeV at 95% CL.
- 1st direct exclusion of particle with mass > 1 TeV at Tevatron!
  - Run 2 with 75 pb^{-1} is more sensitive to highest mass physics than run 1.